U.S. Department
of Transportation

**Pipeline and
Hazardous Materials
Safety Administration**

**East Building, PHH-23
1200 New Jersey Avenue SE
Washington, D.C. 20590**

**COMPETENT AUTHORITY CERTIFICATION
FOR A TYPE B(U)F FISSILE
RADIOACTIVE MATERIALS PACKAGE DESIGN
CERTIFICATE USA/9225/B(U)F-96, REVISION 42**

This certifies that the radioactive material package design described has been certified by the Competent Authority of the United States as meeting the regulatory requirements for a Type B(U)F packaging for fissile radioactive material as prescribed in the regulations of the International Atomic Energy Agency[1] and the United States of America[2].

1. Package Identification - NAC-LWT.

2. Package Description and Authorized Radioactive Contents - as described in U.S. Nuclear Regulatory Commission Certificate of Compliance No. 9225, Revision 50 (attached).

3. Criticality - The minimum criticality safety index is as assigned in NRC Certificate of Compliance. The maximum number of packages per conveyance is determined in accordance with Table X of the IAEA regulations cited in this certificate.

4. General Conditions -

    a. Each user of this certificate must have in his possession a copy of this certificate and all documents necessary to properly prepare the package for transportation. The user shall prepare the package for shipment in accordance with the documentation and applicable regulations.

    b. Each user of this certificate, other than the original petitioner, shall register his identity in writing to the Office of Hazardous Materials Technology, (PHH-23), Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Washington D.C. 20590-0001.

    c. This certificate does not relieve any consignor or carrier from compliance with any requirement of the Government of any country through or into which the package is to be transported.

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[1] "Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), No. TS-R-1 (ST-1, Revised)," published by the International Atomic Energy Agency(IAEA), Vienna, Austria.

[2] Title 49, Code of Federal Regulations, Parts 100-199, United States of America.

d. This certificate provides no relief from the limitations for transportation of plutonium by air in the United States as cited in the regulations of the U.S. Nuclear Regulatory Commission 10 CFR 71.88.

e. Records of Quality Assurance activities required by Paragraph 310 of the IAEA regulations[1] shall be maintained and made available to the authorized officials for at least three years after the last shipment authorized by this certificate. Consignors in the United States exporting shipments under this certificate shall satisfy the applicable requirements of Subpart H of 10 CFR 71.

5. Special Conditions -

a. Tritium producing burnable absorber rods described in paragraph 5(b)(1)(xii) and 5(b)(1)(xv) of the NRC Certificate of Compliance are not authorized by this certificate.

b. Non fissile or fissile exempt quantities of solid, irradiated and contaminated fuel assembly structural or reactor internal component hardware as described in paragraph 5(b)(1)(xvi)

6. Marking and Labeling - The package shall bear the marking USA/9225/B(U)F-96 in addition to other required markings and labeling.

7. Expiration Date - This certificate expires on February 28, 2010. On December 31, 2009, this certificate supersedes all previous revisions of USA/9225/B(U)F-96.

CERTIFICATE USA/9225/B(U)F-96, REVISION 42

This certificate is issued in accordance with paragraph 814 of the IAEA Regulations and Section 173.471 and 173.472 of Title 49 of the Code of Federal Regulations, in response to the December 22, 2008 petition by NAC International, Norcross, GA, and in consideration of other information on file in this Office.

Certified By:

for Robert A. Richard
Deputy Associate Administrator for Hazardous Materials Safety

Jan 08 2009
(DATE)

Revision 42 - Issued to endorse, subject to restrictions of special conditions 1 and 2, U.S. Nuclear Regulatory Commission Certificate of Compliance No. 9225, Revision 50. This revision specifies forms and configurations of ANSTO HIFAR fuel as authorized contents.

NRC FORM 618 (8-2000) 10 CFR 71			U.S. NUCLEAR REGULATORY COMMISSION **CERTIFICATE OF COMPLIANCE FOR RADIOACTIVE MATERIAL PACKAGES**			
1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE		PAGES
9225	50	71-9225	USA/9225/B(U)F-96	1	OF	27

2. PREAMBLE

a. This certificate is issued to certify that the package (packaging and contents) described in Item 5 below meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material."

b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

a. ISSUED TO *(Name and Address)*

NAC International, Inc.
3930 East Jones Bridge Road
Norcross, GA 30092

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

NAC International, Inc., application dated December 10, 2008, as supplemented.

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: NAC-LWT

(2) Description

The LWT is a steel-encased, lead-shielded shipping cask. The cask is designed to transport various radioactive contents as listed in 5.(b)(1). The overall dimensions of the package, with impact limiters, are 232 inches long by 65 inches in diameter. The cask body is approximately 200 inches in length and 44 inches in diameter. The cask cavity is 178 inches long and 13.4 inches in diameter. The volume of the cavity is approximately 14.5 cubic feet.

The cask body consists of a 0.75-inch-thick stainless steel inner shell, a 5.75-inch-thick lead gamma shield, a 1.2-inch-thick stainless steel outer shell, and a neutron shield tank. The inner and outer shells are welded to a 4-inch-thick stainless steel bottom end forging. The cask bottom consists of a 3-inch-thick, 20.75-inch-diameter lead disk enclosed by a 3.5-inch-thick stainless steel plate and bottom end forging. The cask lid is 11.3-inch-thick stainless steel stepped design, secured to a 14.25-inch-thick ring forging with twelve 1-inch diameter bolts. The cask seal is a metallic O-ring. A second teflon O-ring and a test port are provided to leak test the seal. Other penetrations in the cask cavity include the fill and drain ports, which are sealed with port covers and O-rings.

The neutron shield tank consists of a 0.24-inch-thick stainless steel shell with 0.50-inch-thick end plates. The neutron shield region is 164 inches long and 5 inches thick. The neutron shield tank contains an ethylene glycol/water solution that is 1% boron by weight.

The cask is equipped with aluminum honeycomb impact limiters. The top impact limiter has an outside diameter of 65.25 inches and a maximum thickness of 27.8 inches. The bottom impact limiter has an outside diameter of 60.25 inches and maximum thickness of 28.3 inches. Both impact limiters extend 12 inches along the side of the cask body.

5.(a)(2) Description (continued)

The maximum weight of the package is 52,000 pounds and the maximum weight of the contents and basket is 4,000 pounds.

(3) Drawings

(i) The packaging is constructed in accordance with the following Nuclear Assurance Corporation Drawings:

LWT 315-40-01, Rev. 7	Cask Assembly
LWT 315-40-02, Rev. 24 (Sheets 1-2)	Body Assembly
LWT 315-40-03, Rev. 22 (Sheets 1-7)*	Transport Cask Body
LWT 315-40-04, Rev. 10	Cask Lid Assembly
LWT 315-40-05, Rev. 9	Upper Impact Limiter
LWT 315-40-06, Rev. 9	Lower Impact Limiter
LWT 315-40-08, Rev. 18 (Sheets 1-5)	Cask Parts Detail

* Packaging Unit Nos. 1, 2, 3, 4, and 5 are constructed in accordance with Drawing No. LWT 315-40-03, Rev. 6 (Sheets 1-6).

(ii) The fuel assembly baskets are constructed in accordance with the following Nuclear Assurance Corporation and NAC International Drawings:

LWT 315-40-09, Rev. 2	PWR Basket Spacer
LWT 315-40-10, Rev. 7 (Sheets 1-2)	PWR Basket
LWT 315-40-11, Rev. 2	BWR Basket Assembly
LWT 315-40-12, Rev. 3	Metal Fuel Basket Assembly
LWT 315-40-045, Rev. 5	42 MTR Element Base Module
LWT 315-40-046, Rev. 5	42 MTR Element Intermediate Module
LWT 315-40-047, Rev. 5	42 MTR Element Top Module
LWT 315-40-048, Rev. 3	42 MTR Element Cask Assembly
LWT 315-40-049, Rev. 5	28 MTR Element Base Module
LWT 315-40-050, Rev. 5	28 MTR Element Intermediate Module
LWT 315-40-051, Rev. 5	28 MTR Element Top Module
LWT 315-40-052, Rev. 3	28 MTR Element Cask Assembly
LWT 315-40-070, Rev. 5	7 Cell Basket TRIGA Base Module
LWT 315-40-071, Rev. 5	7 Cell Basket TRIGA Intermediate Module
LWT 315-40-072, Rev. 5	7 Cell Basket TRIGA Top Module
LWT 315-40-079, Rev. 5	Transport Cask Assembly, 120 TRIGA Fuel Elements or 480 Cluster Rods
LWT 315-40-080, Rev. 3	7 Cell Poison Basket TRIGA Base Module
LWT 315-40-081, Rev. 3	7 Cell Poison Basket TRIGA Intermediate Module
LWT 315-40-082, Rev. 3	7 Cell Poison Basket TRIGA Top Module
LWT 315-40-083, Rev. 0	Spacer, LWT Cask Assembly TRIGA Fuel
LWT 315-40-084, Rev. 4	LWT Transport Cask Assy, 140 TRIGA Elements

5.(a)(3)(ii) Drawings (continued)

LWT 315-40-085, Rev. 0	Axial Fuel and Cell Block Spacers, MTR, and TRIGA Fuel Baskets
LWT 315-40-090, Rev. 3	35 MTR Element Base Module
LWT 315-40-091, Rev. 3	35 MTR Element Intermediate Module
LWT 315-40-092, Rev. 3	35 MTR Element Top Module
LWT 315-40-094, Rev. 4	35 MTR Element Cask Assembly
LWT 315-40-096, Rev. 3	Fuel Cluster Rod Insert, TRIGA Fuel
LWT 315-40-098, Rev. 4 (Sheets 1-3)	PWR/BWR Rod Transport Canister Assembly
LWT 315-40-099, Rev. 3 (Sheets 1-3)	Can Weldment, PWR/BWR Transport Canister
LWT 315-40-100, Rev. 4 (Sheets 1-5)	Lids, PWR/BWR Rod Transport Canister
LWT 315-40-101, Rev. 0	4 x 4 Insert, PWR/BWR Transport Canister
LWT 315-40-102, Rev. 1	5 x 5 Insert, PWR/BWR Transport Canister
LWT 315-40-103, Rev. 0	Pin Spacer, PWR Transport Canister
LWT 315-40-104, Rev. 4 (Sheets 1-3)	LWT Cask Assembly, PWR/BWR Rod Transport Canister
LWT 315-40-105, Rev. 3 (Sheets 1-2)	PWR Insert, PWR/BWR Transport Canister
LWT 315-40-106, Rev. 1 (Sheets 1-3)	MTR Plate Canister, LWT Cask
LWT 315-40-108, Rev. 1 (Sheets 1-3)	7 Cell Basket, Top Module, DIDO Fuel
LWT 315-40-109, Rev. 1 (Sheets 1-3)	7 Cell Basket, Intermediate Module, DIDO Fuel
LWT 315-40-110, Rev.1 (Sheets 1-3)	7 Cell Basket, Bottom Module, DIDO Fuel
LWT 315-40-111, Rev. 2	LWT Transport Cask Assy DIDO Fuel
LWT 315-40-113, Rev. 0	Spacer, Top Module DIDO Fuel
LWT 315-40-120, Rev. 2 (Sheets 1-3)	Top Module, General Atomics IFM, LWT Cask
LWT 315-40-123, Rev. 1 (Sheets 1-2)	Spacer, General Atomics IFM, LWT Cask
LWT 315-40-124, Rev. 1	Transport Cask Assembly, General Atomics IFM, LWT Cask
LWT 315-40-125, Rev. 3 (Sheets 1-3)	Transport Cask Assembly, Framatome/EPRI, LWT Cask
LWT 315-40-126, Rev. 2 (Sheets 1-2)	Weldment, Framatome/EPRI, LWT Cask
LWT 315-40-127, Rev. 2 (Sheets 1-2)	Spacer Assembly, TPBAR Shipment
LWT 315-40-129, Rev. 1	Canister Body Assembly, Failed Fuel Can, PULSTAR
LWT 315-40-130, Rev. 1	Assembly, Failed Fuel Can, PULSTAR
LWT 315-40-133, Rev. 1 (Sheets 1-2)	Transport Cask Assembly, PULSTAR Shipment, LWT Cask
LWT 315-40-134, Rev. 1	Body Weldment, Screened Fuel Can, PULSTAR Fuel
LWT 315-40-135, Rev. 1	Assembly, Screened Fuel Can, PULSTAR Fuel
LWT 315-40-139, Rev. 1	Transport Cask Assembly, ANSTO Fuel
LWT 315-40-140, Rev. 1 (Sheets 1-2)	Weldment, 7 Cell Basket, Top Module, ANSTO Fuel

5.(a)(3)(ii) Drawings (continued)

LWT 315-40-141, Rev. 1 (Sheets 1-2)	Weldment, 7 Cell Basket, Intermediate Module, ANSTO Fuel
LWT 315-40-142, Rev. 1 (Sheets 1-2)	Weldment, 7 Cell Basket, Base Module, ANSTO Fuel
LWT 315-40-145, Rev. 0 (Sheets 1-2)	Irradiated Hardware, Lid Spacer, LWT Cask
LWT 315-40-148, Rev. 0	LWT Transport Cask Assembly, ANSTO-DIDO Combination Basket

5.(b) Contents

(1) Type and form of material

All contents listed include both unirradiated and irradiated conditions.

(i) PWR fuel assemblies. The maximum fuel assembly weight is 1650 pounds, the maximum average burnup is 35,000 MWd/MTU, the minimum cool time is 2 years, and the maximum initial fuel pin pressure at 70°F is 565 psig. The fuel assemblies consist of uranium dioxide pellets within zirconium alloy type cladding, with the specifications listed below, and with fuel rod pitch, rod diameter, clad thickness, and pellet diameter as described in Table 1.2-5, of the application.

Fuel Type	No. Fuel Rods	Max. Initial Uranium Enrichment (w/o U-235)	Max. Initial Uranium Mass (MTU)	Max. Active Fuel Length (in.)
B&W 15x15	208	3.5	0.4750	144.0
B&W 17x17	264	3.5	0.4658	143.0
CE 14x14	176	3.7	0.4037	137.0
CE 16x16	236	3.7	0.4417	150.0
WE 14x14 Std	179	3.7	0.4144	145.2
WE 14x14 OFA	179	3.7	0.3612	144.0
WE 15x15	204	3.5	0.4646	144.0
WE 17x17 Std	264	3.5	0.4671	144.0

5.(b)(1)(i) PWR fuel assemblies. (continued)

WE 17x17 OFA	264	3.5	0.4282	144.0
Ex/ANF 14x14 WE	179	3.7	0.3741	144.0
Ex/ANF 14x14 CE	176	3.7	0.3814	134.0
Ex/ANF 15x15 WE	204	3.7	0.4410	144.0
Ex/ANF 17x17 WE	264	3.5	0.4123	144.0

(ii) BWR fuel assemblies. The maximum fuel assembly weight is 750 pounds, the maximum average burnup is 30,000 MWd/MTU, the minimum cool time is 2 years, and the maximum initial fuel pin pressure at 70°F is 565 psig. The fuel assemblies consist of uranium dioxide pellets within zirconium alloy type cladding, with the specifications listed below, and with fuel rod pitch, rod diameter, clad thickness, and pellet diameter as described in Table 1.2-6, of the application.

Fuel Type	No. Fuel Rods	No. Water Rods	Max. Initial Uranium Enrichment (w/o U-235)	Max. Initial Uranium Mass (MTU)	Max. Active Fuel Length (in.)
GE 7x7	49	0	4.0	0.1923	146
GE 8x8-1	63	1	4.0	0.1880	146
GE 8x8-2	62	2	4.0	0.1847	150 (1)
GE 8x8-4	60	4	4.0	0.1787	150 (1,2)
GE 9x9	74	2	4.0	0.1854	150 (1,3,4)
	79	2	4.0	0.1979	150 (1,4)
Ex/ANF 7x7	49	0	4.0	0.1960	144
Ex/ANF 8x8-1	63	1	4.0	0.1764	145.2
Ex/ANF 8x8-2	62	2	4.0	0.1793	150
Ex/ANF 9x9	79	2	4.0	0.1779	150
	74	2	4.0	0.1666	150 (3)

(1) Six-inch natural uranium blankets on top and bottom.
(2) One large water hole - 3.2 cm ID, 0.1 cm thickness.
(3) Two large water holes occupying seven fuel rod locations - 2.5 cm ID, 0.07 cm thickness.
(4) Shortened active fuel length in some rods.

5.(b)(1) Type and form of material (continued)

(iii) Deleted.

(iv) MTR fuel elements composed of U-Al, U_3O_8-Al, or U_3Si_x-Al positioned within the MTR fuel basket specified in 5.(a)(3)(ii). Loose fuel plates must meet the requirements of the MTR fuel element content tables and must be loaded into an MTR plate canister prior to shipment. The fuel elements are composed of aluminum clad plates, with initial uranium enrichment up to 94.0 weight percent U-235. The maximum burnup and the minimum cool time shall be consistent with the decay heat limits in Item 5.(b)(2)(iv) and shall be determined using the operating procedures in Section 7.1.5 of the application.

NISTR MTR fuel elements specifications are listed in Item 5.(b)(1)(iv)(a), generic MTR fuel elements are listed in Item 5.(b)(1)(iv)(b), and expanded fuel specifications applicable to LEU MTR fuel (up to 25.0 wt $\%^{235}$U) are listed in Items 5.(b)(1)(iv)(c) and 5.(b)(1)(iv)(d).

(a) NISTR MTR Fuel Content Description

Parameter	Plate	Plate (cut in half)
Enrichment, wt $\%^{235}$U	≤94	
Number of fuel plates	≤17	≤34
^{235}U content per plate	≤22	≤11
Plate thickness (cm)	≥0.115	
Clad Thickness (cm)	≥0.02	
Active fuel width (cm)	≤6.6	
Active fuel height (cm)	≥54 cm	27 to 30
Maximum ^{235}U content per element (g)	≤380	

5.(b)(1) Type and form of material (continued)

(iv) (b) Generic MTR Fuel Content Description

Parameter	Limiting Values[2]					
Enrichment, wt. % ^{235}U	≤94					
Number of fuel plates	≤23	≤19	≤23[1]	≤17	≤19	≤23
^{235}U content per plate	≤18	≤20	≤20[1]	≤21	≤21	≤16.5
Plate thickness (cm)	≥0.115	≥0.115	≥0.123[1]	≥0.115	≥.200	≥0.115
Clad Thickness (cm)	≥0.02					
Active fuel width (cm)	≤6.6	≤6.6	≤6.6	≤6.6	≤6.6	≤7.3
Active fuel height (cm)	≥56					
^{235}U content per element (g)	≤380[2]					

Notes:

1. HEU (>90 wt% ^{235}U enriched) MTR fuel having 23 plates with up to 20 g of ^{235}U per plate, with a minimum plate thickness of 0.123 cm, must have at least 2.0 cm of non-fuel material at the ends of each element. This fuel may also be loaded up to 460 g ^{235}U per element.

2. At enrichments ≤25 wt% ^{235}U, MTR fuel elements with extended fuel characteristics may be loaded with the specifications defined in 5.(b)(1)(iv)(c).

5.(b)(1) Type and form of material (continued)

(iv) (c) Expanded LEU MTR Fuel Content Description

Parameter	Base	≤7.0 cm Active Fuel Width			≤7.1 cm Active Fuel Width		≤7.15 cm Active Fuel Width		
Enrichment, wt. % ^{235}U	≤25	≤25			≤25		≤25		
Number of fuel plates	≤23	≤23			≤17	≤23	≤22	≤23	≤23
^{235}U content per plate	≤22	≤22	≤22	≤21.5	≤22		≤22	≤21.5	≤22
Plate thickness (cm)	≥0.115	≥0.119	≥0.115	≥0.115	≥0.115	≥0.200	≥0.119		
Clad Thickness (cm)	≥0.02								
Active fuel width (cm)	≤6.6	≤7.0			≤7.1		≤7.15		
Active fuel height (cm)	≥56	≥56	≥63	≥56	≥56		≥56	≥56	≥61
^{235}U content per element (g)	≤420	≤470			≤470		≤470		

5.(b)(1) Type and form of material (continued)

(iv) (d) Expanded LEU MTR Fuel Content Description for High Fissile Material Mass

Parameter	Limiting Value
Enrichment, wt.% ^{235}U	≤25
Number of fuel plates	≤23
^{235}U content per plate (g)	≤32
Plate thickness (cm)	≥0.115
Clad thickness (cm)	≥0.02
Active fuel width (cm)	≤7.3
Active fuel height (cm)	≥56
^{235}U content per element (g)	≤640

(v) Metallic fuel rods containing natural enrichment uranium pellets with aluminum cladding 0.080-inches thick. The fuel pellet diameter is 1.36 inches and the maximum fuel rod length is 120.5 inches. The maximum weight of uranium per rod is 54.5 kg with a maximum average burnup of 1,600 MWd/MTU and a minimum cooling time of one year.

(vi) TRIGA damaged and undamaged fuel elements. TRIGA fuel elements that have a cladding breach that allows the escape of gas or intrusion of water are considered damaged and will be loaded and transported in a sealed damaged fuel can.

5.(b)(1) Type and form of material (continued)

(vi) (a) TRIGA fuel elements acceptable for loading in the poisoned TRIGA basket and meeting the following specifications:

	TRIGA HEU (Notes 1, 2, 6, & 7)	TRIGA LEU (Notes 1, 2, 6, & 7)	TRIGA LEU (Notes 1, 2, 6, & 7)
Fuel Form	Clad U-ZrH rod	Clad U-ZrH rod	Clad U-ZrH rod
Maximum Element Weight, lbs	13.2	13.2	13.2
Maximum Element Length, in	47.74	47.74	47.74
Element Cladding	Stainless Steel	Stainless Steel	Aluminum
Clad Thickness, in	0.02	0.02	0.03
Active Fuel Length, in	15	15	14-15 (Note 4)
Element Diameter, in	1.478 max.	1.478 max.	1.47 max.
Fuel Diameter, in	1.435 max.	1.435 max.	1.41 max.
Maximum Initial U Content/Element, kilograms	0.196	0.845	0.205
Maximum Initial ^{235}U Mass, grams	137	169	41
Maximum Initial ^{235}U Enrichment, weight percent	70	20	20
Zirconium Mass, grams (Note 5)	2060	1886 – 2300	2300
Hydrogen to Zirconium Ratio, max. (Note 5)	1.6	1.7	1.0
Maximum Average Burnup, MWd/MTU	460,000 (80% ^{235}U)	151,100 (80% ^{235}U)	151,100 (80% ^{235}U)
Minimum Cooling Time	90 days (Note 3)	90 days (Note 3)	90 days (Note 3)

Notes:
1. Mixed TRIGA LEU and HEU contents authorized.
2. TRIGA Standard, instrumented and fuel follower control rod type elements authorized.
3. Maximum decay heat of any element is 7.5 watts.
4. Aluminum clad fuel with 14 inch active fuel is solid and has no central hole with a zirconium rod.
5. Zirconium mass and H/Zr ratio apply to the fuel material (U-Zr-H_x) and do not include the center zirconium rod.
6. Listed TRIGA fuel elements have a 0.225-inch diameter zirconium rod in the center.
7. Dimensions listed are as-fabricated (unirradiated) nominal values.

5.(b)(1) Type and form of material (continued)

(vi) (b) TRIGA fuel elements acceptable for loading in the nonpoisoned TRIGA basket and meeting the following specifications:

	TRIGA HEU (Notes 1, 2, & 6)	TRIGA LEU (Notes 1, 2, & 6)	TRIGA LEU (Notes 1, 2, & 6)
Fuel Form	Clad U-ZrH rod (Note 4)	Clad U-ZrH rod (Note 4)	Clad U-ZrH rod (Note 4)
Maximum Element Weight, lbs	13.2	13.2	13.2
Maximum Element Length, in	47.74	47.74	47.74
Element Cladding	Stainless Steel	Stainless Steel	Aluminum
Minimum Clad Thickness, in	0.01	0.01	0.01
Maximum Element Diameter, in	1.5 max.	1.5 max.	1.5 max.
Active Fuel Length, in	15	15	15
Maximum Initial U Content/Element, kilograms	0.196	0.845	0.205
Maximum Initial ^{235}U Mass, grams	137	169	41
Maximum Initial ^{235}U Enrichment, weight percent	70	20	20
Hydrogen to Zirconium Ratio, max. (Note 5)	2.0	2.0	2.0
Maximum Average Burnup, MWd/MTU	460,000 (80% ^{235}U)	151,100 (80% ^{235}U)	151,100 (80% ^{235}U)
Minimum Cooling Time	90 days (Note 3)	90 days (Note 3)	90 days (Note 3)

Notes:

1. Mixed TRIGA LEU and HEU contents authorized.
2. TRIGA Standard, instrumented and fuel follower control rod type elements authorized.
3. Maximum decay heat of any element is 7.5 watts.
4. Element may contain a zirconium rod in the center.
5. H/Zr ratio applies to the fuel material (U-Zr-H_x) and does not include the center zirconium rod.
6. Dimensions listed are as-fabricated (unirradiated) nominal values.

5.(b)(1) Type and form of material (continued)

(vii) TRIGA fuel cluster rods. TRIGA HEU fuel cluster rods have a maximum average burnup of 600,000 MWd/MTU (80% ^{235}U depletion) and a minimum cooling time of 90 days. TRIGA LEU fuel cluster rods have a maximum average burnup of 140,000 MWd/MTU (80% ^{235}U depletion) and a minimum cooling time of 90 days. TRIGA fuel cluster rods must meet the following specifications prior to irradiation:

	TRIGA Fuel Cluster Rods	
	HEU	LEU
Fuel Form	Clad U-ZrH rod	
Maximum Rod Weight, lbs	1.5	
Maximum Rod Length, in	31	
Rod Cladding	Incoloy 800	
Minimum Clad Thickness, in	0.015	
Maximum Active Fuel Length, in	22.5	
Maximum Fuel Pellet Diameter, in	0.53	
Maximum U Content/Rod, grams	48.6	289.5
Maximum ^{235}U Mass, grams	45.4	55
Maximum ^{235}U Enrichment, weight percent	93.3	20
Maximum Zirconium Mass, grams	421	357
Hydrogen to Zirconium Ratio, max.	1.7	

NOTE: TRIGA fuel cluster rods that have a cladding breach that allows the escape of gas or intrusion of water are considered damaged and will be loaded and transported in a sealed damaged fuel can.

(viii) High burnup PWR rods, consisting of uranium dioxide pellets within zirconium alloy type cladding. The maximum uranium enrichment is 5 weight percent U-235, the maximum active fuel length is 150 inches, and the maximum pellet diameter is 0.3765 inches. The maximum burnup is 80,000 MWd/MTU, and the minimum cool time is 150 days.

5.(b)(1) Type and form of Material (continued)

(ix) High burnup BWR rods, consisting of uranium dioxide pellets within zirconium alloy type cladding. The maximum uranium enrichment is 5 weight percent U-235, the maximum active fuel length is 150 inches, and the maximum pellet diameter is 0.490 inch. The maximum burnup is 80,000 MWd/MTU and the minimum cool time is between 150 - 270 days, as specified in the table below:

BWR Fuel Type Array Size	Burnup, b (GWd/MTU)	Minimum Cool Time (days)
7 x 7	$b \leq 60$ $60 < b \leq 70$ $70 < b \leq 80$	210 240 270
8 x 8[1]	$b \leq 80$	150

Note 1: Includes rods from all larger BWR assembly arrays (e.g., 9 x 9, 10 x 10)

(x) Intact or degraded clad DIDO fuel elements composed of U-Al, U_3O_8-Al, or U_3Si_x-Al plates fabricated into four concentric tubes of varying diameters. The fuel elements have an initial enrichment up to 94.0 weight percent U-235. Maximum degraded clad allowable per element is ≤ 5% surface area. Degraded clad DIDO fuel elements are to be loaded into an aluminum damaged fuel can (DFC) per Figure 1.2.3-18 of the application. The fuel elements shall have the specifications listed below:

Parameter	LEU[(1)]	MEU[(1)]	HEU[(1)]
Maximum ^{235}U content per Element	≤ 190 g	≤ 190 g	≤ 190 g
Maximum Uranium content per Element	≤ 1000 g	≤ 475.0 g	≤ 211.1g
Minimum Fuel Tube Thickness	0.130 cm	0.130 cm	0.130 cm
Minimum Clad Thickness	0.025 cm	0.025 cm	0.025 cm
Maximum Outer Diameter	9.535 cm	9.535 cm	9.535 cm
Minimum Inner Diameter	5.88 cm	5.88 cm	5.88 cm
Minimum Initial Enrichment	19 wt% ^{235}U	40 wt% ^{235}U	90 wt% ^{235}U

1 The maximum burnup and minimum cool time shall be consistent with the decay heat limits in Item 5.(b)(2)(xi)(a) and (b) and shall be determined using the operating procedures in Section 7.1.4 of the application.

5.(b)(1) Type and form of material (continued)

(xi) General Atomics (GA) Irradiated Fuel Material (IFM) consisting of two separate types of fuel materials: (a) High Temperature Gas Cooled Reactor (HTGR); and (b) Reduced-Enrichment Research and Test Reactor (RERTR) type TRIGA fuel entities.

(a) GA HTGR IFM comprised of four forms: fuel particles (kernels), fuel particles (coatings), fuel compacts (rods), and fuel pebbles. Fuel particles (kernels) are solid, spheridized, high-temperature sintered fully-densified, ceramic kernel substrate, composed of UO_2, UCO_2, $(Th,U)C_2$, or $(Th,U)O_2$. Fuel particles (coatings) are solid , spheridized, isotropic, discrete multi-layered fuel particle coatings with chemical composition including pyrolitic-carbon (PyC) and silicon carbide (SiC). Fuel compacts (rods) are multi-coated ceramic fuel particles, bound in solid, cylindrical, injection molded, high-temperature heat-treated compacts which are composed of carbonized graphite shim, coke, and graphite powder. Fuel pebbles are multi-coated fuel particles, bound in solid, spherical injection-molded, high-temperature heat-treated pebbles composed of carbonized graphite shim, coke and graphite powder. Initial enrichment of the HTGR IFM varies from 10.0 to 93.15 wt% ^{235}U.

(b) GA RERTR IFM comprised of irradiated TRIGA fuel elements which contain three distinct mass loadings of uranium of 20, 30, and 45 wt% U. The average mass of the fuel portion of the elements is 551 g with a maximum initial enrichment of 19.7 wt% U-235.

GA IFM content description:

	GA HTGR IFM	GA RERTR IFM
Fuel material	UO_2, UCO, UO_2 $(Th,U)C_2$, $(Th,U)O_2$	U-ZrH metal alloy
Maximum fuel weight, lbs	23.52	23.73
Maximum overall length, in	n/a	29.92
Maximum active fuel length, in	n/a	22.05
Fuel rod cladding	n/a	Incoloy 800
Maximum Uranium, kg U	0.21	3.86
Maximum initial ^{235}U, wt%	93.15	19.7
Maximum Activity, Ci	483	2920

5.(b)(1) Type and form of material (continued)

(xii) Tritium-producing burnable absorber rods (TPBARs), as described in Section 1.2.3.6 of the application. Each TPBAR is approximately 153 inches in length and 0.381 inches in diameter and is stainless steel clad. The TPBARs contain lithium aluminate annular pellets, with an inner zircaloy liner and an outer nickel-plated zircaloy tube. Each TPBAR contains a maximum of 1.2 grams tritium. The minimum cool time is 30 days.

(xiii) Intact or damaged PULSTAR fuel elements, including fuel debris, pieces and nonfuel components of PULSTAR fuel assemblies as specified below.

Description	Value
Maximum Pellet Diameter (inch)	0.423
Minimum Element (Rod) Cladding Thickness (inch)	0.0185
Minimum Element (Rod) Diameter (inch)	0.470
Maximum Active Fuel Height (inch)	24.1
Nominal Element (Rod) Length (inch)	26.2
Nominal Assembly Length (inch)	38
Maximum Assembly or Loaded Can Weight (lb)	80
Maximum PULSTAR Can Content Weight (lb)	39.6
Maximum Enrichment (wt % ^{235}U)	6.5
Maximum ^{235}U Content per Element (g)	33
No. of Elements (Rods) per Assembly	25
No. of Elements (Rods) per Can[1]	≤25
Maximum Depletion (% ^{235}U)	45
Minimum Cooling Time (yrs)	1.5
Maximum Heat Load per Assembly (W)	30
Maximum Heat Load per Element (W)	1.2

[1] Damaged PULSTAR fuel elements, including fuel debris, pieces and nonfuel components of PULSTAR fuel assemblies must be loaded into a PULSTAR can. The contents of a PULSTAR can are restricted to the equivalent of the fuel material in 25 intact PULSTAR fuel elements and of the displaced volume of 25 intact PULSTAR fuel elements.

5.(b)(1) Type and form of material (continued)

(xiv) Intact or degraded clad ANSTO fuel consisting of spiral fuel assemblies and MOATA plate bundles. Maximum degraded clad allowable per element is ≤ 5% surface area. Degraded clad ANSTO fuel elements are to be loaded into an aluminum damaged fuel can (DFC) per Figure 1.2.3-18 of the application.

Spiral fuel assemblies consist of 10 curved uranium-aluminum alloy fuel plates between an inner and an outer aluminum shell, with the following fuel parameters:

Parameter	Limiting Values
Number of fuel plates per assembly	10
Maximum ^{235}U content per assembly (g)	160
Maximum enrichment (wt % ^{235}U)	95
Maximum assembly weight (lb)	18
Minimum plate thickness (cm)	0.124
Minimum active fuel height (cm)	59.075

MOATA plate bundles consist of uranium-aluminum alloy fuel plates with aluminum cladding, with the following specifications:

Parameter	Limiting Values
Maximum number of fuel plates per assembly	14
Maximum ^{235}U content per plate (g)	22.3
Maximum enrichment (wt % ^{235}U)	92
Maximum plate spacer thickness (cm)	0.18
Maximum active fuel width (cm)	7.32
Maximum bundle weight (lb)	18

(xv) Segmented TPBARs and associated segmentation debris resulting from post-irradiation examination, as described in Section 1.2.3.6 of the application. Each equivalent TPBAR contains a maximum of 1.2 grams of tritium. The minimum cool time is 90 days.

(xvi) Solid, irradiated and contaminated fuel assembly structural or reactor internal component hardware, which may include fissile material, provided the quantity of fissile material does not exceed a Type A quantity and qualifies as an exempt quantity under 10 CFR 71.15.

(xvii) PWR MOX (mixed oxide) undamaged fuel rods consisting of uranium and plutonium and plutonium dioxide pellets within zirconium alloy type cladding. The plutonium enrichment is 7.0 weight percent maximum and 2.0 weight percent minimum, the maximum active fuel rod length is 153.5 inches, and the maximum pellet diameter is 0.3765 inch. The maximum burnup is 62,500 MWd/MTU and the minimum cool time is 90 days.

5.(b)(2) Maximum quantity of material per package

Not to exceed 4,000 pounds, including contents and fuel assembly basket or other internal support structure.

(i) For the contents described in Item 5.(b)(1)(i): one PWR assembly positioned within the PWR fuel assembly basket. Maximum decay heat not to exceed 2.5 kilowatts per PWR assembly.

(ii) For the contents described in Item 5.(b)(1)(ii): two BWR assemblies positioned within the BWR fuel assembly basket. Maximum decay heat not to exceed 1.1 kilowatts per BWR assembly.

(iii) Deleted.

(iv) For MTR fuel elements as described in Item 5.(b)(1)(iv):

Up to 42 fuel elements positioned within the MTR fuel assembly basket (7 fuel elements per basket module). Each of the MTR basket cell openings may contain a loose plate canister. The contents of each loose plate canister are limited to the number of fuel plates, dimensions, and masses that are equivalent to an intact MTR fuel element, as specified in Item 5.(b)(1)(iv).

(a) The maximum decay heat is not to exceed 1.26 kilowatts per package, with each MTR fuel assembly basket module not to exceed 210 watts.

(b) HEU, MEU, and LEU MTR fuel elements with decay heat not exceeding 30 watts per element may be loaded in any basket position.

(c) Mixed HEU, MEU, and LEU MTR contents, with decay heat limits as specified above, are authorized.

(d) MTR fuel elements with degraded or mechanically damaged cladding are authorized, provided the total surface area of through-clad corrosion and/or mechanical damage does not exceed 5% of the total surface area of the damaged element.

(e) For HEU-MTR fuel elements only, the center fuel element in any basket module is not to exceed 120 watts. The two exterior fuel elements vertically in-line with the center assembly for transport are not to exceed 70 watts.

(f) MTR fuel elements containing more than 470 g ^{235}U (more than 22 g ^{235}U per plate) are limited to up to four elements loaded in basket positions 4, 5, 6, and 7 of a seven-element basket per Figure 7.1-1 of the application. Basket positions 1, 2, and 3 are to be blocked by spacer hardware.

5.(b)(2) Maximum quantity of material per package (continued)

(v) For the contents described in Item 5.(b)(1)(v): up to 15 intact metallic fuel rods positioned within the appropriate basket. Maximum decay heat not to exceed 0.036 kilowatts per rod. Total weight of all rods not to exceed 1,805 pounds.

(vi) For failed metallic fuel rods of the type described in Item 5.(b)(1)(v):

(a) Up to six canisters containing one defective metallic fuel rod per canister. The canisters are 2.75-inch I.D. failed fuel rod canisters as shown on Nuclear Assurance Corporation Drawing No. 340-108-D2, Rev. 10, and are placed in a six-hole liner as shown on Nuclear Assurance Corporation Drawing No. 315-040-43, Rev. 1. The maximum decay heat load for a defective metallic fuel rod is limited to 5 watts; or

(b) Up to three canisters containing either up to three defective metallic fuel rods per canister or up to 10 failed fuel filters per canister. The canisters are 4.00-inch I.D. failed fuel rod canisters as shown on Nuclear Assurance Corporation Drawing No. 340-108-D1, Rev. 10, and are placed in a three-hole basket as shown on Nuclear Assurance Corporation Drawing No. 315-40-12, Rev. 3. The weight of the filters is limited to 125 pounds per canister. For canisters containing fuel rods, the maximum decay heat load is 15 watts per canister; and for canisters containing filters, the maximum decay heat load is 5 watts per canister.

5.(b)(2) Maximum quantity of material per package (continued)

(vii)(a) For TRIGA fuel elements as described in Item 5.(b)(1)(vi)(a):

Up to 140 intact fuel elements in the TRIGA fuel package with poisoned baskets. Up to four fuel elements per basket cell and up to seven cells per basket may be loaded. Damaged TRIGA fuel elements or fuel element debris (up to a total of two equivalent elements) shall be transported in a sealed damaged fuel can (one damaged fuel can per cell). The sealed cans are to be in accordance with NAC International Drawing Nos. 315-40-086, 315-40-087, and 315-40-088.

Mixed intact and damaged fuel contents and fuel debris are authorized. Base and top fuel basket modules may contain intact fuel elements or sealed damaged fuel cans containing damaged fuel and fuel debris. A maximum of seven damaged fuel cans is authorized per top and base basket modules with a maximum of 14 per package. Intermediate fuel basket modules may contain only intact TRIGA fuel elements.

The maximum decay heat shall not exceed 7.5 watts per TRIGA fuel element (or equivalent for damaged fuel) and 1050 watts per package. The cask and baskets must be configured as shown in NAC International Drawing Nos. 315-40-084, 315-40-080, 315-40-081, and 315-40-082.

(vii)(b) For TRIGA fuel elements as described in Item 5.(b)(1)(vi)(b):

Up to 120 intact fuel elements in the TRIGA fuel package with non-poisoned basket. Up to four fuel elements per basket cell only loaded in the six periphery cells. TRIGA fuel elements or sealed cans may not be loaded in the center cell of the non-poisoned basket. Damaged TRIGA fuel elements or fuel debris (up to two equivalent elements) shall be transported in a sealed damaged fuel can (one damaged fuel can per cell). The sealed cans are to be in accordance with NAC International Drawing Nos. 315-40-086, 315-40-087, and 315-40-088.

Mixed intact and damaged fuel contents and fuel debris are authorized. Base and top fuel basket modules may contain intact fuel elements or sealed damaged fuel cans containing damaged fuel or fuel debris. A maximum of six damaged fuel cans is authorized only in the periphery cells per top and base basket modules with a maximum of 12 per package. Intermediate fuel basket modules may contain only intact TRIGA fuel elements.

Maximum decay heat not to exceed 7.5 watts per TRIGA fuel element (or equivalent for damaged fuel) and 900 watts per package. Fuel may not be loaded in the center cell of the non-poisoned TRIGA fuel basket. The cask and baskets must be configured as shown in NAC International Drawing Nos. 315-40-070, 315-40-071, and 315-40-072, and 315-40-079.

5.(b)(2) Maximum quantity of material per package (continued)

(viii) For TRIGA fuel cluster rods as described in Item 5.(b)(1)(vii):

Maximum decay heat not to exceed 1.875 watts per TRIGA fuel cluster rod (or equivalent for failed fuel) and 1050 watts per package. TRIGA fuel cluster rods must be positioned in either the non-poisoned TRIGA fuel basket or in the poisoned TRIGA fuel basket. Fuel may not be loaded in the center cell of the non-poisoned TRIGA fuel basket. The non-poisoned basket must be configured as shown in NAC International Drawing Nos. 315-40-070, 315-40-071, and 315-40-072, and the poisoned basket must be configured as shown in NAC International Drawing Nos. 315-40-080, 315-40-081, and 315-40-082.

Up to 480 intact cluster rods per package in the non-poisoned TRIGA fuel baskets (up to six periphery cells loaded with 16 cluster rods each), and up to 560 intact cluster rods per package in the poisoned TRIGA fuel baskets (up to 7 total cells loaded with 16 cluster rods each). TRIGA fuel cluster rods must be positioned within the fuel rod inserts as shown on NAC International Drawing No. 315-40-096.

Damaged TRIGA fuel cluster rods or cluster rod debris (up to six equivalent rods) shall be transported in a sealed damaged fuel can. The sealed cans are to be in accordance with NAC International Drawing Nos. 315-40-086, 315-40-087, and 315-40-088.

Mixed intact and damaged fuel contents and fuel debris are authorized. Base and top fuel basket modules may contain intact fuel cluster rods or sealed DFCs. Intermediate fuel basket modules may contain only intact fuel cluster rods.

(ix) For high burnup PWR fuel rods, as described in Item 5.(b)(1)(viii): up to 25 fuel rods. Maximum decay heat not to exceed 2.3 kilowatts per package.

Intact individual rods may be placed either in an irradiated or unirradiated fuel assembly lattice (skeleton) or in a fuel rod insert. The PWR fuel assembly lattice must be transported in the PWR basket.

Up to 14 of the 25 fuel rods may be classified as damaged. Damaged fuel rods may include fuel debris, particles, loose pellets, and fragmented rods. Damaged fuel rods must be placed in a fuel rod insert. Damaged fuel rods may also be placed in individual failed fuel rod capsules, as shown in Figure 1.2.3-11 of the application, prior to placement in the fuel rod insert. Irradiated guide tubes and guide tube segments may be placed in the fuel rod insert. The fuel rod insert must be transported in a PWR/BWR transport canister, which is positioned in the PWR insert in the PWR basket.

(x) For high burnup BWR fuel rods, as described in Item 5.(b)(1)(ix): up to 25 fuel rods. Maximum decay heat not to exceed 2.1 kilowatts per package.

Intact individual rods may be placed either in a fuel assembly lattice or in a fuel rod insert. The BWR fuel assembly lattice must be transported in the PWR insert in the PWR basket.

5.(b)(2) Maximum quantity of material per package (continued)

Up to 14 of the 25 fuel rods may be classified as damaged. Damaged fuel rods may include fuel debris, particles, loose pellets, and fragmented rods. Damaged fuel rods must be placed in a fuel rod insert. Damaged fuel rods may also be placed in individual failed fuel rod capsules, as shown in Figure 1.2.3-11 of the application, prior to placement in the fuel rod insert. The fuel rod insert must be transported in a PWR/BWR transport canister, which is positioned in the PWR insert in the PWR basket.

(xi) For DIDO fuel as described in Item 5.(b)(1)(x):

(a) Up to 42 DIDO fuel elements with a maximum decay heat not to exceed 25 watts per DIDO fuel element, provided the top basket fuel element active fuel region is spaced a minimum 3.7 inches from the bottom of the cask lid. Spacing of the active fuel may be accomplished by fuel element hardware, lid spacer, or a combination thereof. Maximum decay heat is 1.05 kilowatts per package. At a top basket active fuel region to cask lid spacing of less than 3.7 inches, the maximum decay heat not to exceed 18 watts per DIDO fuel element and a total of 756 watts per package. The DIDO fuel elements are to be loaded into a DIDO basket configured as shown in NAC International Drawing No. 315-40-111.

(b) A mixed fuel load of up to 42 DIDO fuel elements and spiral and MOATA fuel assemblies [per item 5.(b)(1)(xiv)] in an ANSTO-DIDO combination basket configured as shown in NAC International Drawing No. 315-40-148 consisting of a top ANSTO basket module per NAC International Drawing No. 315-40-140; four intermediate DIDO basket modules per NAC International Drawing No. 315-40-109; and one bottom DIDO basket module per NAC International Drawing No. 315-40-110. DIDO fuel elements loaded into intermediate and bottom basket modules are limited to ≤18 Watts. Up to seven degraded clad DIDO, spiral, and/or MOATA fuel assemblies in DFCs per Figure 1.2.3-18 of the application, or intact DIDO, spiral, and/or MOATA assemblies may be loaded in the top ANSTO module. The per element or DFC heat load limits for the top ANSTO module are: DIDO fuel element with or without DFC is 10 Watts; spiral fuel element in DFC is 10 Watts and 15.7W without DFC; and MOATA fuel element in DFC is 1 Watt and 3 Watts without DFC. Maximum heat load per package is 753 Watts.

(xii) For GA IFM as described in Item 5.(b)(1)(xi):

(a) Mixture of fuel particles (kernels and coatings), fuel compacts (rods), and fuel pebbles, packaged in its own Fuel Handling Unit (FHU).

GA HTGR FHU consists of two redundant canisters. GA HTGR IFM is packaged inside a primary canister with welded closure, as shown in General Atomics Drawing No. 032237, Rev. B, "HTGR Primary Enclosure." The primary canister is packaged inside a secondary canister with welded closure, as shown in General Atomics Drawing No. 032231, Rev. A, "HTGR Secondary Enclosure."

GA HTGR FHU total maximum decay heat not to exceed 2.05 watts, and maximum loaded weight not to exceed 71.5 lbs.

(b) Twenty irradiated TRIGA fuel elements; 13 of the elements are intact, and the remaining 7 are sectioned. GA RERTR IFM is packaged in its own FHU.

5.(b)(2) Maximum quantity of material per package (continued)

GA RERTR FHU consists of two redundant canisters. GA RERTR IFM is packaged inside a primary canister with welded closure, as shown in General Atomics Drawing No. 032236, Rev. B, "RERTR Primary Enclosure." The GA RERTR IFM primary canister is packaged inside a secondary canister with welded closure, as shown in General Atomics Drawing No. 032230, Rev. A, "RERTR Secondary Enclosure."

GA RERTR FHU total maximum decay heat not to exceed 11 watts, and maximum loaded weight not to exceed 76.0 lbs.

(xiii) For TPBARs as described in Item 5.(b)(1)(xii):

Up to 300 TPBARs, including a maximum of 2 damaged rods, positioned within a consolidation canister, as shown in Figure 1.2.3-10 of the application. The consolidation canister is transported in a TPBAR basket assembly. The maximum decay heat is 2.31 watts per rod and 693 watts per package. The maximum weight of the TPBARs and the consolidation canister is 1,000 pounds. Consolidation canisters with fewer than 300 TPBARs may also contain stainless steel spacers of various geometries. The total weight and volume of the reduced TPBAR contents plus the spacers must be less than or equal to the weight and volume of 300 TPBARs.

(xiv) For PULSTAR fuel as described in Item 5.(b)(1)(xiii):

Up to 700 intact or damaged PULSTAR fuel elements in either assembly or element form, including fuel debris, pellets, pieces and nonfuel components of PULSTAR fuel assemblies. The contents of a PULSTAR can are restricted to the equivalent of the fuel material in 25 intact PULSTAR fuel elements and of the displaced volume of 25 intact PULSTAR fuel elements.

(xv) For ANSTO fuel as described in Item 5.(b)(1)(xiv):

(a) Up to 42 spiral fuel assemblies, MOATA plate bundles, or any combination of spiral fuel assemblies and MOATA plate bundles. ANSTO fuel must be loaded within ANSTO basket modules. Spiral fuel assemblies may be cropped by removing nonfuel-bearing hardware to fit the ANSTO basket modules. Fuel assemblies that are cropped, but are otherwise intact, may be considered intact. For spiral fuel assemblies, the maximum decay heat per assembly is 15.7 watts. The minimum cool time as a function of burnup shall be consistent with the maximum decay heat limit and shall be determined using the procedures for medium enriched DIDO fuel in Section 7.1.4 of the application; the minimum cool time may not be less than 270 days. For MOATA plate bundles, the maximum heat load per bundle is 3 watts, and the minimum cool time is 10 years.

5.(b)(2) Maximum quantity of material per package (continued)

(b) A mixed fuel load of up to 42 spiral and MOATA fuel assemblies and DIDO fuel elements [per item 5.(b)(1)(x)] in an ANSTO basket configured as shown in NAC International Drawing No. 315-40-139. Degraded clad elements placed in DFCs per Figure 1.2.3-18 of the application or intact DIDO fuel elements are limited to loading in the top ANSTO basket module. Maximum heat load per DIDO element is 10W. Degraded clad spiral and MOATA fuel assemblies in DFCs are also limited to loading in the top ANSTO basket module. Spiral fuel assemblies placed into DFCs are limited to a maximum of 10W and MOATA plate bundles loaded in DFCs are limited to 1W. Spiral fuel elements not placed in DFCs are limited to 15.7W and MOATA plate bundles not placed in DFCs are limited to a maximum of 3W with a minimum cool time of 10 years.

(xvi) For segmented TPBARs as described in Item 5.(b)(1)(xv):

Up to 55 equivalent TPBARs as segments and segmentation debris, placed within a welded waste container, as shown in Figure 1.2.3-16 of the application. The waste container is transported in a TPBAR basket assembly. The maximum decay heat is 2.31 watts per equivalent TPBAR and 127 watts per package. The maximum weight of the segmented TPBARs and the TPBAR waste container is 700 pounds.

(xvii) For solid irradiated hardware as described in Item 5.(b)(1)(xvi):

Up to 4,000 pounds, including spacers, dunnage and containers, and meeting the gamma source defined in Table 1.2-13 of the application. An irradiated hardware spacer source, per NAC Drawing No. 315-40-145, shall be installed.

(xviii) For intact PWR MOX fuel rods as described in Item 5.(b)(1)(xvii):

Up to 16 undamaged irradiated PWR MOX rods or a combination of PWR MOX and high burnup PWR fuel rods as described in Item 5.(b)(1)(viii). Maximum decay heat not to exceed 2.3 kW per package. Individual PWR MOX and PWR UO_2 fuel rods shall be placed in a 5x5 insert loaded into a screened or free flow rod canister in accordance with NAC International Drawing No. 315-40-104, for transport. Up to nine nonstainless burnable poison rods (BPRs) may be loaded in the spare locations in the 5x5 insert. The PWR/BWR fuel rod canister shall be transported in the PWR basket and the PWR insert installed in the cask cavity.

5(c) Criticality Safety Index (CSI)

For PWR fuel assemblies described in 5(b)(1)(i) and limited in 5(b)(2)(i)	100
For BWR fuel assemblies described in 5(b)(1)(ii) and limited in 5(b)(2)(ii)	5.0
For MTR fuel elements described in 5(b)(1)(iv) and limited in 5(b)(2)(iv)	0.0
For metallic fuel rods described in 5(b)(1)(v) and limited in 5(b)(2)(v) and (vi)	0.0
For TRIGA fuel elements (in poisoned TRIGA fuel baskets) described in 5(b)(1)(vi)(a) and limited in 5(b)(2)(vii)(a)	0.0
For TRIGA fuel elements (in nonpoisoned TRIGA fuel baskets) described in 5(b)(1)(vi)(b) and limited in 5(b)(2)(vii)(b)	12.5
For TRIGA fuel cluster rods described in 5(b)(1)(vii) and limited in 5(b)(2)(viii)	0.0
For high burnup PWR rods described in 5(b)(1)(viii) and limited in 5(b)(2)(ix)	0.0
For high burnup BWR rods described in 5(b)(1)(ix) and limited in 5(b)(2)(x)	0.0
For DIDO fuel elements described in 5(b)(1)(x) and limited in 5(b)(2)(xi)	12.5
For General Atomic Irradiated Fuel Material (GA IFM) described in 5(b)(1)(xi) and limited in 5(b)(2)(xii)	0.0
For TPBARS and segmented TPBARS described in 5(b)(1)(xii) and 5(b)(1)(xv) and limited in 5(b)(2)(xiii) and 5(b)(2)(xvi)	0.0
For intact (uncanned) PULSTAR fuel described in 5(b)(1)(xiii) and limited in 5(b)(2)(xiv)	0.0
For (canned) PULSTAR fuel described in 5(b)(1)(xiii) and limited in 5(b)(2)(xiv) – for a package with any number of PULSTAR cans	33.4

5(c) Criticality Safety Index (CSI)

For ANSTO fuel described in 5(b)(1)(xiv) and limited in 5(b)(2)(xv)	0.0
For solid irradiated hardware described in 5(b)(1)(xvi) and limited in 5(b)(2)(xvii)	0.0
For PWR MOX rods described in 5.(b)(1)(xvii) and limited by 5(b)(2)(xviii)	0.0
For a mixed fuel load of DIDO and ANSTO fuel elements described in 5(b)(1)(x) and 5(b)(1)(xiv) and limited by 5(b)(2)(xi)(b) and 5(b)(2)(xv)(b)	0.0

6. Known or suspected damaged fuel assemblies (rods) or elements, and fuel with cladding defects greater than pin holes and hairline cracks are not authorized, except as described in Items 5.(b)(1)(x); 5.(b)(1)(xiv); 5.(b)(2)(iv)(d); 5.(b)(2)(vi); 5.(b)(2)(vii)(a); 5.(b)(2)(vii)(b); 5.(b)(2)(viii); 5.(b)(2)(ix); 5.(b)(2)(x); 5.(b)(2)(xi); 5.(b)(2)(xiv); and 5.(b)(2)(xv).

7. The cask must be dry (no free water) when delivered to a carrier for transport.

8. Bolt torque: The cask lids bolts must be torqued to 260 +/- 20 ft-lbs. The bolts used to secure the alternate vent and drain port covers must be torqued to 100 +/- 10 inch-lbs. The bolts used to secure the Alternate B port covers must be torqued to 285 +/- 15 inch-lbs.

9. Prior to each shipment, the package must be leak tested to 1×10^{-3} std cm^3/sec, except that replaced seals must be leak tested to 2.0×10^{-7} std cm^3/sec (He). Prior to first use, and at least once within the 12-month period prior to each subsequent use, the package must be leak tested to 2.0×10^{-7} std cm^3/sec (He).

10. In addition to the requirements of Subpart G of 10 CFR Part 71:

    (a) The metallic O-ring lid seal must be replaced prior to each shipment; and

    (b) Each package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application; and

    (c) The package shall be prepared for shipment and operated in accordance with the Package Operations of Chapter 7 of the application. If the cask is loaded under water or water is introduced into the cask cavity, the cask must be vacuum dried as described in Chapter 7 of the application. The cask cavity must be backfilled with 1.0 atm of helium when shipping PWR or BWR assemblies, individual PWR and BWR rods, or TPBAR contents.

11. When shipping PWR, BWR, PWR MOX, MTR, DIDO assemblies, TRIGA fuel elements, TRIGA fuel cluster rods, high burnup PWR or BWR rods, GA IFM, PULSTAR fuel elements, spiral fuel assemblies, and MOATA plate bundles, the neutron shield tank must be filled with a mixture of water and ethylene

glycol which will not freeze or precipitate in a temperature range from -40 °F to 250 °F. The water and ethylene glycol mixture must contain at least 1% boron by weight.

12. A personnel barrier must be used when shipping PWR or BWR assemblies. Shipments of MTR, DIDO fuel assemblies, TRIGA fuel elements, TRIGA fuel cluster rods, high burnup PWR or BWR rods, PWR MOX rods, TPBAR contents, PULSTAR fuel elements, spiral fuel assemblies, MOATA plate bundles, or irradiated hardware must use the ISO container or a personnel barrier.

13. Packages used to ship metallic fuel rods may be shipped in a closed shipping container provided that the closed container, the cask tie-down and support system and transport vehicle (trailer) meet the applicable requirements of the Department of Transportation. When the cask is shipped in a closed shipping container, the center of gravity of the combined cask, closed shipping container and trailer must not exceed 75 inches.

14. For shipment of TPBAR contents:

    (a) Prior to first use for shipment of TPBAR contents, each packaging must be hydrostatic pressure tested to 450 +15/-0 psig, as described in Section 8.1.2 of the application;

    (b) The package must be marked with Package Identification Number USA/9225/B(M)-96;

    (c) The package must be configured as shown in NAC International Drawing No. 315-40-128, Rev. 2, for the applicable TPBAR contents; and

    (d) Prior to each shipment, after loading, each cask containment seal must be tested to show no leakage greater than 2 x 10^{-7} std-cm^3/s (helium).

15. For shipment of PULSTAR fuel:

    (a) Intact fuel elements may be configured as PULSTAR fuel assemblies, may be placed into a TRIGA fuel rod insert (a 4 x 4 rod holder), or may be loaded into PULSTAR fuel cans. Intact PULSTAR fuel assemblies and PULSTAR fuel elements in a TRIGA fuel rod insert may be loaded in any module of the 28 MTR basket assembly. PULSTAR fuel cans may only be loaded into the top or base module of the 28 MTR basket assembly.

    (b) Damaged PULSTAR fuel elements and nonfuel components of PULSTAR fuel assemblies must be loaded into PULSTAR cans. Damaged PULSTAR fuel, including fuel debris, pellets or pieces, may be placed in an encapsulating rod prior to loading into a PULSTAR fuel can. PULSTAR fuel cans may only be loaded into the top or base module of the 28 MTR basket assembly.

    (c) Loading of modules with mixed PULSTAR payload configuration is allowed.

16. Transport by air is not authorized.

17. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.17.

18. Revisions 48 and 49 of this certificate may be used until December 31, 2009.

19. Expiration Date: February 28, 2010.

REFERENCES

NAC International, Inc., application dated December 10, 2008.

NAC International, Inc., supplements dated August 12 and 27, November 18, and December 4 and 10, 2008.

FOR THE U. S. NUCLEAR REGULATORY COMMISSION

Eric J. Benner, Chief
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Date: December 22, 2008

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT

Docket No. 71-9225
Model No. NAC-LWT Package
Certificate of Compliance No. 9225
Revision No. 50

SUMMARY

By letter dated August 12, 2008, as supplemented August 27, November 18, and December 4 and 10, 2008, NAC International (NAC or the applicant) requested a revision to Certificate of Compliance (CoC) No. 9225 for the Model No. NAC-LWT packaging. NAC requested the incorporation of the ANSTO HIFAR fuel as either intact, degraded clad, and/or disassembled assemblies in different loading configurations as authorized contents.

The approval of the ANSTO HIFAR contents are necessary to support the transport of additional foreign research reactor (FRR) fuel in support of the U.S. Department of Energy's National Nuclear Security Administration FRR fuel acceptance program.

Twenty-five NAC International Drawings were revised and one new drawing was added to update the CoC for this revision request and to incorporate changes due to several letter authorizations issued recently to accommodate minor fabrication difficulties identified by NAC.

By letter dated December 10, 2008, NAC submitted a consolidated Safety Analysis Report (SAR) that was utilized to finalize this revision.

Accordingly, CoC No. 9225 has been amended based on the statements and representations in the application, and staff agrees that the changes do not affect the ability of the package to meet the requirements of Title 10 of the Code of Federal Regulations (10 CFR) Part 71.

EVALUATION

The submittal was evaluated against the regulatory standards in 10 CFR Part 71, including the general standards for all packages, standards for fissile material packages, and performance standards under normal conditions of transport (NCT) and hypothetical accident conditions (HAC). Staff reviewed the application using the guidance in NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel."

Based on the statements and representations in the application, as supplemented, and the conditions listed in the CoC, the staff has reasonable assurance that the design has been adequately described and evaluated and meets the requirements of 10 CFR Part 71.

REFERENCES

NAC International, application dated December 10, 2008.

NAC International, supplements dated August 12 and 28, November 18, and December 4, 2008.

1.0 GENERAL INFORMATION

1.1 Package Description

The Model No. NAC-LWT package is shipped by truck, within an ISO container, or by railcar, as a Type B(U)F-96 package, as defined in 10 CFR 71.4. There were no changes to the package in this application.

1.2 Packaging Drawings

The applicant submitted twenty-five revised drawings. The revised drawings include:

LWT 315-40-02, Rev. 24 (Sheets 1-2)	Body Assembly
LWT 315-40-08, Rev. 18 (Sheets 1-5)	Cask Parts Detail
LWT 315-40-45, Rev. 5	42 MTR Element Base Module
LWT 315-40-46, Rev. 5	42 MTR Element Immediate Module
LWT 315-40-47, Rev. 5	42 MTR Element Top Module
LWT 315-40-49, Rev. 5	28 MTR Element Base Module
LWT 315-40-50, Rev. 5	28 MTR Element Intermediate Module
LWT 315-40-51, Rev. 5	28 MTR Element Top Module
LWT 315-40-70, Rev. 5	7 Cell Basket TRIGA Base Module
LWT 315-40-71, Rev. 5	7 Cell Basket TRIGA Intermediate Module
LWT 315-40-72, Rev. 5	7 Cell Basket TRIGA Top Module
LWT 315-40-80, Rev. 3	7 Cell Poison Basket TRIGA Base Module
LWT 315-40-81, Rev. 3	7 Cell Poison Basket TRIGA Intermediate Module
LWT 315-40-82, Rev. 3	7 Cell Poison Basket TRIGA Top Module
LWT 315-40-90, Rev. 3	35 MTR Element Module
LWT 315-40-91, Rev. 3	35 MTR Element Intermediate Module

LWT 315-40-92, Rev. 3	35 MTR Element Top Module
LWT 315-40-98, Rev. 4 (Sheets 1-3)	PWR/BWR Rod Transport Canister Assembly
LWT 315-40-100, Rev. 4 (Sheets 1-5)	Lids, PWR/BWR Rod Transport Canister
LWT 315-40-104, Rev. 4 (Sheets 1-3)	LWT Cask Assembly, PWR/BWR Rod Transport Canister
LWT 315-40-111, Rev. 2	LWT Transport Cask Assy DIDO Fuel
LWT 315-40-139, Rev. 1	Transport Cask Assembly, ANSTO Fuel
LWT 315-40-140, Rev. 1 (Sheets 1-2)	Weldment, 7 Cell Basket, Top Module, ANSTO Fuel
LWT 315-40-141, Rev. 1 (Sheets 1-2)	Weldment, 7 Cell Basket, Intermediate Module, ANSTO Fuel
LWT 315-40-142, Rev. 1 (Sheets 1-2)	Weldment, 7 Cell Basket, Base Module, ANSTO Fuel

The drawings were revised to incorporate changes due to several letter authorizations issued recently to accommodate minor fabrication difficulties identified by NAC and to support this revision.

The applicant submitted one new license drawing:

LWT 315-40-148, Rev. 0	LWT Transport Cask Assembly, ANSTO-DIDO Combination Basket

The drawing was added to incorporate the new ANSTO-DIDO combination basket.

1.3 Contents

The ANSTO HIFAR fuel includes ANSTO spiral (Mark III), MOATA plate (Mark II), and DIDO (Mark IV) fuel either intact, degraded clad, and/or disassembled assemblies. There are optional damaged fuel cans (DFCs) to facilitate handling of degraded clad or disassembled Mark II, III, and IV fuel elements. The requested loading combinations are described below.

- A mixed fuel load of up to 42 DIDO fuel elements and spiral and MOATA fuel assemblies in an <u>ANSTO-DIDO combination basket</u> consisting of a top ANSTO basket module, four intermediate DIDO basket modules, and one bottom DIDO basket module. Up to seven degraded clad DIDO, spiral, and/or MOATA fuel assemblies in DFCs or intact DIDO, spiral, and/or MOATA assemblies may be loaded in the top ANSTO module. The per element or DFC heat load limits for the top ANSTO module are: DIDO fuel element with or without DFC is 10 Watts; spiral fuel element in DFC is 10 Watts and 15.7 Watts without DFC; and MOATA fuel element in DFC is 1 Watt and 3 Watts without DFC. DIDO fuel elements loaded into intermediate and bottom basket modules are limited to ≤18 Watts. Maximum heat load per package is 753 Watts.

- A mixed fuel load of up to 42 spiral and MOATA fuel assemblies and DIDO fuel elements in an ANSTO basket. Degraded clad elements placed in DFCs or intact DIDO fuel elements are limited to loading in the top ANSTO basket module. Degraded clad spiral and MOATA fuel assemblies in DFCs are also limited to loading in the top ANSTO basket module. Maximum heat load per DIDO element is 10 Watts. Spiral fuel assemblies placed into DFCs are limited to a maximum of 10 Watts and MOATA plate bundles loaded in DFCs are limited to 1 Watt. Spiral fuel elements not placed in DFCs are limited to 15.7 Watts and MOATA plate bundles not placed in DFCs are limited to a maximum of 3 Watts with a minimum cool time of 10 years.

2.0 STRUCTURAL

The staff reviewed the application to revise the Model No. NAC-LWT package structural design and evaluation to assess whether the package will remain within the allowable values or criteria for normal conditions of transport (NCT) and hypothetical accident conditions (HAC) as required in 10 CFR Part 71. This application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 2 (Structural Review) of NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel."

2.1 Structural Review Description

NAC has requested an approval for a revision to CoC No. 9225 to incorporate the ANSTO HIFAR fuel as either intact, degraded clad, and/or disassembled assemblies in different loading configurations as authorized contents.

The existing Safety Analysis Report (SAR), and NAC License Drawings were revised to reflect inclusion of these additional contents and submitted for the NRC staff review. No changes were made to the structural evaluation.

2.2 Material Properties

The request is to add degraded DIDO fuel (Mark IV), degraded ANSTO spiral fuel (Mark III) either as fuel elements or disassembled plates, and degraded MOATA fuel (Mark II) either as fuel elements or disassembled plates as approved contents all in damaged fuel cans for transport in the NAC-LWT cask. "Fuel elements" in this usage are equivalent to the normal usage of "fuel assemblies." In addition, intact DIDO fuel elements were requested as approved contents in a different location in the cask. Since intact DIDO elements had been previously approved as contents, there are no materials concerns about these fuel elements and they were not evaluated. A definition of "degraded fuel" was provided.

All three types of fuel elements consist of a homogeneous mixture UAl alloy clad with aluminum plates. There could be up to 14 plates either flat or curved, depending on the assembly design, contained in an aluminum superstructure. The damaged fuel cans are made of 6061 aluminum and vented at both the top and bottom with screens. The bottom of the can is welded and the top of the can is screwed in place.

The damaged fuel cans or intact elements are placed in a 304 stainless steel basket. The basket materials, and weld specifications are noted on drawing 315-40-140. The welds are made according to ASME Sec IX, and visually inspected per ASME Sec V, Article 1 & 9. Weld acceptance is per Section III, NG-5360.

The cask has a 304 stainless steel body and closure lid. The inner and outer shells are XM-19 stainless steel. The cask has a lead (Pb) gamma shield and a borated ethylene glycol and water mixture neutron shield. Since the cask has previously been approved for transport, it will not be reevaluated. The neutron and gamma shield were evaluated to determine if they can withstand the maximum expected accident temperatures.

The three materials questions of concern are: 1) Interactions of the exposed fuel with other components, (Al +SS +UAl), 2) sufficient temperature margin for components during normal transport, and 3) containment source terms.

Interactions of the exposed fuel with other components, (Al +SS + UAl)

The main interaction concern reviewed is the generation of hydrogen during the corrosion of the aluminum if the cask cavity is not dried and a galvanic couple is set up between the aluminum cladding and the stainless steel in the basket. According to Section 7.1 of the SAR, if the package is loaded underwater, the cask cavity will be drained then vacuum dried before backfilling with helium. The cavity will be evacuated to 10 torr and held at that pressure for at least 10 minutes. If the pressure has not risen by more than 5 torr over the hold time, the cavity will be deemed dry. This procedure can be repeated if necessary. This drying method is acceptable to the staff for aluminum fuel. Using this drying procedure, no galvanic couples are expected to occur. The backfill should prevent oxidation of the aluminum to occur.

2.3 Structural Evaluation

The Staff has reviewed the NAC-LWT amendment request to add ANSTO HIFAR spent fuel configurations and noted that changes that were made in the package contents and subsequent mass are bounded by previous structural evaluations. In reviewing these changes, the staff found that the variations were minor and had no effect on the ability of the package to perform its safety function.

2.4 Conclusion

Based on the review of the application, the staff found reasonable assurance that the applicant has demonstrated that the NAC-LWT package for transport of the ANSTO HIFAR spent fuel meets the structural requirements for NCT and HAC as required by 10 CFR Part 71.

3.0 THERMAL

The staff reviewed the application to revise the Model No. NAC-LWT package thermal design and evaluation to assess whether the package temperatures will remain within their allowable values or criteria for NCT and HAC as required in 10 CFR Part 71. This application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 3 (Thermal Review) of NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel."

3.1 Thermal Review Description

This amendment incorporates the addition of ANSTO HIFAR fuel [ANSTO (spiral), MOATA (plate) and DIDO (4 concentric plates)]. It also includes the addition of DFCs to contain and facilitate handling of degraded cladding or disassembled fuel elements for these fuel types. These fuels are transported in a new ANSTO-DIDO basket which includes six inline axial modules, with each module accommodating up to seven fuel assemblies for a total maximum number of 42 fuel assemblies per LWT cask. The top module near the loading end is dedicated to degraded fuel or disassembled fuel, loaded into DFCs, and the remaining modules accommodate intact DIDO or ANSTO fuel assemblies. Degraded fuel has been defined as fuel with failed cladding but will not result in formation of significant quantities of fuel debris during transport.

3.2 Thermal Evaluation

For the canned configurations, the applicant is lowering their heat load to compensate for the potential minimal increase in thermal resistance of the aluminum DFC. There are various configurations of fuel arrangements which were evaluated by the applicant and are discussed as follows:

- Degraded clad DIDO fuel will be placed in a DFC and loaded in the top module of an ANSTO-DIDO basket or standard ANSTO basket. The heat load for the degraded DIDO fuel will be limited to 10 Watts per fuel assembly versus 18 Watts in the original design basis of the ANSTO basket and versus 25 Watts in the original design basis of the DIDO basket. Since the applicant limits the maximum heat load of the non-DFC modules to 15.7 Watts and 18 Watts for the ANSTO and DIDO fuel, respectively, the original design basis will be maintained (for loading into the ANSTO-DIDO combination basket assembly).

- Intact DIDO fuel assemblies will be loaded in the top module of an ANSTO-DIDO basket or standard ANSTO basket. The heat load for the intact DIDO fuel will be limited to 10 Watts per fuel assembly versus 18 Watts in the original design basis of the ANSTO basket and versus 25 Watts in the original design basis of the DIDO basket. Since the applicant limits the maximum heat load of the non-DFC modules to 15.7 Watts and 18 Watts for the ANSTO and DIDO fuel, respectively, the original design basis will be maintained (for loading into the ANSTO-DIDO combination basket assembly).

- Degraded and disassembled ANSTO fuel assemblies will be placed in a DFC (1/2 of an assembly per DFC) and loaded in the top module of an ANSTO-DIDO basket or standard ANSTO basket. The heat load per DFC will be limited to 10 Watts. The original design basis heat loads for the ANSTO basket and the DIDO basket is 18 Watts per assembly and 25 Watts per assembly, respectively. The applicant states that these analyses bound this DFC loading of ANSTO fuel. The staff agrees that thermal loading will be bounding as long as the applicant limits the thermal input from the adjacent models to 18 Watts maximum, as indicated in SAR Sections 3.4.1.15.5 and 3.4.1.15.6.

- Degraded MOATA plates (disassembled assembly) will be placed in a DFC and loaded in the top module of an ANSTO-DIDO basket or standard ANSTO basket. The heat load limit will be 1 Watt which is bounded by the MOATA design basis heat load limit of 3 Watts. Based on the staff's evaluation, NAC revised Section 3.4.1.15, "Thermal Evaluation for ANSTO-DIDO Combination Basket," to clarify the thermal design basis of the subject basket. It appears that the 3 Watts limit per MOATA assembly is not based on an associated cladding temperature limit but rather a loading restriction for this fuel type. Since the cladding for the MOATA is aluminum, it has the same temperature limit as the other aluminum clad fuels which have higher heat loads. An analysis of the spiral aluminum clad ANSTO fuel, with an assembly heat limit of 15.7 Watts, for all modules loaded as such, resulted in a maximum cladding temperature of 250°F which bounds the lower heat load MOATA fuel loaded into a combination basket.

- Intact ANSTO fuel maximum heat load is limited to 15.7 Watts for all intact ANSTO fuel loaded into the ANSTO-DIDO combination basket assembly, except for within the DFC. The staff finds this acceptable since the original design basis heat load for ANSTO fuel is 18 Watts.

- DIDO fuel has a maximum heat load of 18 Watts loaded into any of the bottom 5 DIDO basket modules of the ANSTO-DIDO combination basket assembly. If loaded into the top module the heat load limit is 10 Watts per assembly whether it is intact or degraded. This configuration is bounded by the 25 Watts heat load per assembly used in the DIDO evaluation in Section 3.4.1.8.1.

Maximum temperatures of many cask components were calculated for each fuel and allowable atmosphere under normal and accident conditions of transport. The components of interest were: 1) Liquid neutron shield (ethylene glycol), 2) Outer and inner shields (stainless steel), 3) gamma shield (Pb), 4) basket (304 SS), and 5) fuel (UAl). The temperatures of the steels were too low to be of concern. The ethylene glycol was below the flash and boiling point, and the lead was well below the melting point. There were no temperature issues with these components. The creep of the aluminum and UAl components for the maximum was evaluated under its own deadload at both the normal and accident maximum temperature for the one year maximum transport duration and found to be minimal.

For the proposed fuel types included in the ANSTO-DIDO combination basket the applicant does not discuss specific temperatures of important to safety components, nor does it provide the staff of any safety margin that may be present. However, ample references are provided in the bounding analyses described elsewhere in the SAR to allow the reviewer to ascertain that material temperature limits are not being exceeded.

3.3 Conclusion

Based on the review of the application, the staff found reasonable assurance that the applicant has demonstrated that the NAC-LWT package for transport of the ANSTO HIFAR fuel meets the thermal requirements for NCT and HAC as required by 10 CFR Part 71.

4.0 CONTAINMENT

The staff reviewed the application to revise the Model No. NAC-LWT package to verify that the package containment design has been described and evaluated under NCT and HAC as required in 10 CFR Part 71. This application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 4 (Containment Review) of NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel."

4.1 Containment System Design

The ANSTO HIFAR fuel will be transported in a leaktight containment boundary, which includes metallic containment seals on the closure lid and the Alternate B port covers for the vent and drain ports.

4.2 Containment Evaluation

Containment source terms

The DIDO containment analysis is used to bound the spiral and MOATA fuels. The containment analysis for the DIDO (SAR Section 4.5.7) and the similar aluminum MTR fuel (SAR Section 4.5.5) use the release fractions given in WSRC-TR-98-00317)[1] The release fractions given in this reference, Table 2, are the release fractions determined for LWR UO_2 based fuel with Zircaloy cladding. The document WSRC-TR-98-00317 provided some basis for using the release fractions developed for commercial LWR fuel for the UAl metallic alloy fuel. However, the staff did not agree sufficient information was provided to demonstrate that all the release fraction values for the LWR fuel bound those for the UAl fuel. Therefore, the application was revised to specify a leak-tight testing sensitivity of the containment boundary in accordance with ANSI-N14.5-1997. The following source term discussion explains the release fractions that were acceptable, and the reasons for not fully accepting all of the WSRC-TR-98-00317 release fractions for UAl fuel.

The fission gas release fraction is based on a trap-detrap mechanism coupled with diffusion of the gas through the matrix and or grain boundaries of the fuel. The trap-detrap part of the mechanism is difficult to model and evaluate and was assumed to contribute zero time to the gas release. The diffusion was modeled using the relative gas in a flat plate. A nominal value of 15% release was obtained in the reference. This value will depend though on the temperature of the plate, duration of the diffusion, and the use of the proper diffusion constant, i.e., bulk or grain boundary. None of these parameters are given in the reference to conclude if it is applicable to UAl fuel.

The values of the volatile release for both normal and accident transport condition are based on release measurements from irradiated UAl samples heated up to the melting point. The data was reasonable and sufficient to accept the values for the volatile release rates as given.

"Crud" is a colloquial term for corrosion and wear products (rust particles, etc.) that become radioactive (i.e., activated) when exposed to radiation and may deposit on nuclear fuel during reactor operations. The term "crud" in this case refers to the spallation of the oxide layer that forms when the fuel was in the reactor and storage pool and, subsequently, in a moist atmosphere in the cask. The value of this term was based on two fuel properties: the thickness of the oxide layer that is formed, and the spallation of this oxide layer. The corrosion is dependent on the quality of the water and can range from 1-2 microns over years in very good quality water to much thicker layers in poor quality water. At 200°C for some unknown period of time <3.7 microns of oxide was measured. The application did not specify the quality of the reactor or pool water, temperature that the fuel saw in these locations, or the time of residence. Therefore, the accuracy of the oxide layer calculations could not be verified. The oxide on the aluminum is very tenacious and has been experimentally verified to be vigorously scraped to be removed. The staff believes the 15% spallation may be an overestimate,

[1] DW Vinson, PS Blanton, RL Sindelar, and NC Iyer, "Bases for Containment Analysis for Transportation of Aluminum-Based Spent Nuclear Fuel," Oct. 1998, WSRC-TR-98-00317

but quantitative data would be needed to justify a lower and more realistic value. The release fraction for the normal and accident conditions should be approximately the same.

A through-wall penetration and exposure of the fuel surface area is the mechanism need for fines release. Corrosion of this exposed area occurs while the fuel is in the reactor or, more likely, the pool, since the corrosion probably starts on handling scratches of the oxide layer formed in the reactor. The fines release fraction is dependent on three terms: the exposed fuel surface area, the depth of corrosion of the fuel, and the spallation of the corroded fuel. Since the exposed fuel meat is expected to behave the same as the exposed cladding, the formation of the corroded fuel and its spallation will be similar to that discussed above for the cladding oxide layer with the possible difference in time duration. The degraded and undamaged fuel is defined in the SAR (Table 1.1.1) as fuel having no more the 5% of the fuel meat surface area exposed.

In summary, the application did not provide sufficient basis for all the release fractions being applicable to aluminum based fuel with a UAl metallic alloy fuel meat. For these proposed contents, the staff does not endorse the WSRC-TR-98-00317 release fractions developed or measured for LWR fuel for use in containment analysis of aluminum based fuel, without additional supporting information and data. However, the applicant has specified testing the transportation cask to the leaktight criteria of ANSI 14.5-1997 for these requested contents. Based upon the specification to test the cask containment system to the leaktight criteria, and changing the casks configuration to support leaktight testing, the staff concludes that this amendment of the NAC-LWT meets the containment requirements for 10 CFR Part 71.

4.3 Conclusion

Based on the statements and representations in the application, staff agrees that the applicant has shown that the use of the NAC-LWT for transport of the ANSTO HIFAR fuel meets the requirements of 10 CFR Part 71 for the containment.

5.0 SHIELDING

The staff reviewed the application to revise the Model No. NAC-LWT package to verify that the shielding design has been described and evaluated under NCT and HAC, as required in 10 CFR Part 71. This application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 5 (Shielding Review) of NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel."

5.1 Shielding Evaluation

For a previous licensing action (requested on April 17, 2006, and resulting in Revision 41 of Certificate of Compliance No. 9225), the applicant performed a shielding evaluation to show that the Spiral and MOATA fuel assemblies are bounded by the DIDO fuel assemblies listed in 5(b)(1)(x) of the certificate. For the current amendment, the applicant relied on this previous shielding analysis and provided a discussion to justify why the current amendment does not require a change in that previous analysis.

This discussion encompassed three areas. First, the ANSTO basket has slightly thicker tubes than the DIDO basket, so placing DIDO fuel in the ANSTO basket will not cause a higher dose rate. Second, the source for each payload type has not changed. Third, placing fuel into DFCs, especially given the lower heat load limits imposed, will have no adverse effects on dose rates.

5.2 Conclusion

Based on review of the statements and representations in the application, the staff concludes that the applicant has shown that the shielding design for the NAC-LWT containing the mixed ANSTO-DIDO payload configuration has been adequately described and evaluated and that the package meets the shielding requirements of 10 CFR Part 71.

6.0 CRITICALITY

The staff reviewed the application to revise the Model No. NAC-LWT package to verify that the criticality design has been described and evaluated under NCT and HAC, as required in 10 CFR Part 71. This application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 6 (Criticality Review) of NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel."

6.1 Criticality Design

The application for amendment to Certificate of Compliance No. 9225 requests permission to transport the following contents using the Model No. NAC-LWT:

1. Degraded-clad (damaged) DIDO fuels in Damaged Fuel Canister (DFC) loaded in an ANSTO top module,
2. Intact DIDO fuel element loaded in an ANSTO top module,
3. Degraded-clad spiral fuel elements (disassembled) in a DFC loaded into the top basket of ANSTO fuel module in the standard ANSTO basket assembly or in the top module of an ANSTO-DIDO combination basket assembly, and
4. Degraded-cladding MOATA plate elements (disassembled) in a DFC loaded into an ANSTO top basket of either a standard or ANSTO-DIDO combined module.

For these fuels, up to seven degraded-clad DIDO assemblies or spiral fuel assemblies, or MOATA plates in the DFC may be loaded in the top module of an NAC-LWT ANSTO/DIDO fuel package.

The applicant provided, in Chapter 6 of the revised Safety Analysis Report (SAR), a criticality safety evaluation for the packages with the requested contents.

6.2 Criticality Evaluation

Chapter 6 of the SAR provides criticality safety analyses for the DIDO fuel, ANSTO fuel with degraded clad, and mixed ANSTO/DIDO fuel packages. The maximum U-235 enrichment is 94 wt% for the DIDO HEU fuel, 92.0 wt% for MOATA fuel, and 95.0 wt% for the ANSTO spiral fuel. The transportation packages for uniform load of each of these fuel types/modules have previously been authorized except for the ANSTO spiral fuel, for which the cask was authorized for maximum enrichment of 85 wt% U-235. However, for the packages for 95 wt% enrichment ANSTO spiral fuel, the total U-235 weight per element is limited to 160 grams of U-235 per fuel element, which is the same as that of the 85 wt% enrichment fuel.

The applicant provided additional criticality safety analyses for the degraded-clad fuel and the mixed DIDO and ANSTO spent fuel transportation packages, with U-235 enrichment of 95 wt% for the ANSTO spiral fuel, under both NCT and HAC. The CSAS25 module of the SCALE 4.3 code system was used for the criticality analyses. Section 6.4.11 of the revised SAR provides discussion of the criticality safety evaluations for spent fuel transportation packages with various combinations of the DIDO and ANSTO fuels. Tables 6.4.11-1 through 6.4.11-7 provide the evaluation results for these packages. The most reactive configuration is the package with the combination of five DIDO baskets containing DIDO fuel and one top ANSTO fuel basket containing ANSTO spiral fuel or MOATA fuel plate with a 0.5326 cm plate pitch. The k_{safe} for this package is 0.8291. The Criticality Safety Index for this package is 0.0.

6.3 Conclusion

The staff reviewed the criticality safety analyses for the NAC-LWT ANSTO fuel package presented in the revised Safety Analysis Report. The staff also performed confirmatory analyses for the most reactive configuration using the CSAS25 module of the SCALE-5 code system with the 238 group cross section library.

Based on the results of its review and analyses, the staff concludes that the applicant has demonstrated with a reasonable assurance that the Model No. NAC-LWT package for mixed DIDO and ANSTO spent fuel with intact or degraded-clad elements continue to meet the criticality safety requirements of 10 CFR Part 71. The staff determined that transportation of previously approved fuel, but with degraded clad, does not impose a significant effect to the criticality safety assessment on these packages. The packages containing increased-enrichment (95 wt%) spiral fuels do not cause a significant change in the package reactivity because the total U-235 content per element is limited to be the same as that of the previously approved (85 wt%) spiral fuel. The most reactive package provides a bounding case for all requested DIDO/ANSTO packages.

7.0 PACKAGE OPERATIONS

Chapter 7 of the SAR provides procedures for package loading, unloading, and preparation of the empty package for transport. Sections 7.1.3, 7.1.4, 7.1.5, and 7.1.6 provide revised operating procedures for loading mixed DIDO and ANSTO spent fuel baskets into the NAC-LWT cask and procedures for loading damaged mixed DIDO and ANSTO fuel with degraded-clad into Damaged Fuel Cans. This included specification of using a cask tested to a leak-tight testing sensitivity in accordance with ANSI-N14.5-1997. Other minor changes were also made.

The staff reviewed the Operating Procedures in Chapter 7 of the SAR to verify that the package will be operated in a manner that is consistent with its design evaluation. On the basis of its evaluation, the staff concludes that the combination of the engineered safety features and the operating procedures provide adequate measures and reasonable assurance for safe operation of the proposed mixed DIDO and ANSTO spent fuel in accordance with 10 CFR Part 71. Further, the CoC is conditioned such that the package must be prepared for shipment and operated in accordance with the Operating Procedures specified in Chapter 7 of the Safety Analysis Report.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The staff reviewed the revisions to Chapter 8 of the application to verify that the revised acceptance tests for the packaging meet the requirements of 10 CFR Part 71.

To support this revision request, Sections 8.1 and 8.2 of the SAR were revised to describe the requirements for acceptance testing and maintenance of the leaktight containment boundary.

Based on the statements and representations in the application, the staff concludes that the revised acceptance tests for the packaging meet the requirements of 10 CFR Part 71. Further, the CoC is conditioned to specify that each package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application.

CONDITIONS

The CoC has been revised as follows:

Condition Nos. 5(a)(3)(i) and 5(a)(3)(ii):

Twenty-five drawings were revised and one new drawing was added.

Condition No. 5(b)(1)(x):

Details on the type and form of material were added for the additional contents of the degraded clad DIDO fuel.

Condition No. 5(b)(1)(xiv):

Details on the type and form of material were added for the additional contents of the degraded clad ANSTO spiral and MOATA. The enrichment was changed for the ANSTO spiral fuel.

Condition No. 5(b)(2)(iv):

Specifies the definition of the degraded clad MTR fuel.

Condition Nos. 5(b)(2)(xviii), 5(b)(2)(xi), and 5(b)(2)(xv):

Provides for the maximum quantity of material per package for the additional contents of the ANSTO HIFAR fuel.

Condition Nos. 5(b)(vii)(a), 5(b)(vii)(b), 5(b)(viii), 5(b)(2)(xiii), 5(b)(2)(xvi), and 5(b)(2)(xviii):

Editorial changes were made for clarity.

Condition No. 5(c):

A mixed fuel load of DIDO and ANSTO fuel elements were added to the contents with a criticality safety index of 0.0.

Condition No. 6:

The ANSTO HIFAR fuel was added to the condition.

Condition No. 9:

The leakage rate was corrected.

Condition Nos. 16 and 17:

These conditions were deleted because of redundancy. Additionally, the rest of conditions were renumbered.

Condition No. 18 (formerly numbered 20):

Allows the use of Revisions 48 and 49 of this certificate for one year.

CONCLUSION

Based on the statements and representations in the application, as supplemented, and the conditions listed above, the staff concludes that the Model No. NAC-LWT package design has been adequately described and evaluated and that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9225, Revision No. 50,
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U.S. Department
of Transportation

**Pipeline and
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Safety Administration**

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CERTIFICATE NUMBER: USA/9225/B(U)F-96, Revision 42

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